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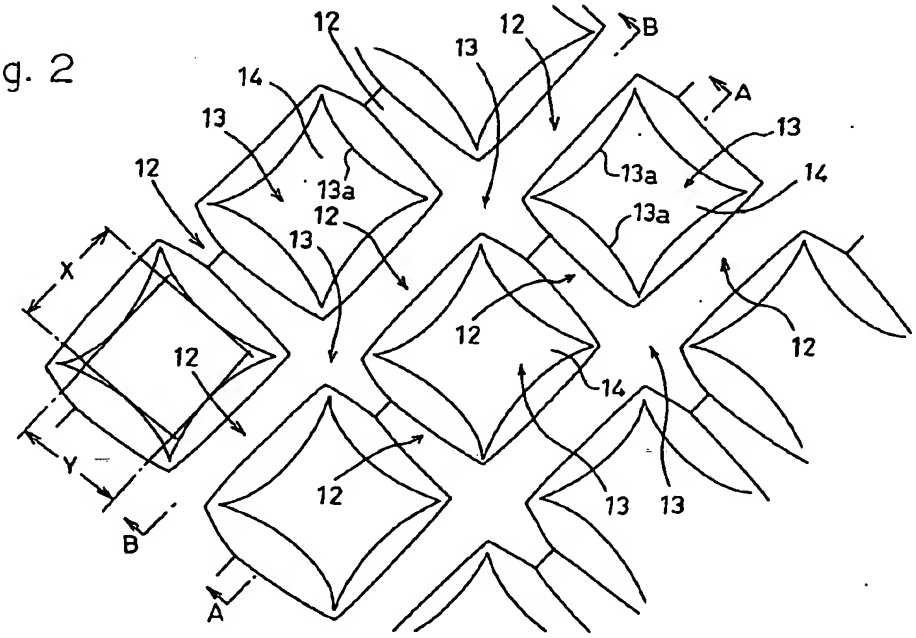
(54) THIN, MESHY POROUS BODY AND METHOD OF MANUFACTURING THE POROUS BODY

(57) This invention provides a thin meshy porous body which is made of a metal, a resin, or paper, and which may be suitably used as a core member for a battery electrode or various filter members. Front and rear faces of a thin plate member are embossed so that concave and convex portions of a conical shape are opposite to each other, and an opening is formed in a tip end of each of the convex portions in at least one face.

Fig. 2



EP 1 289 034 A1

Description

Technical Field

[0001] The present invention relates to a thin meshy porous body which is made of a metal, a resin, or paper, and which may be used as a core member for a battery electrode, various filter members, or the like, and also to a method of manufacturing such a thin meshy porous body.

Background Art

[0002] Conventionally, as a thin meshy porous body which is made of a metal, and which is used as, for example, a porous electrode core member for a nickel-metal-hydride battery or the like, or various filter members such as an air filter or an oil mist filter, there are a perforated metal and a foamed metal.

[0003] In a perforated metal, the framework is formed by a pressing process. Therefore, a perforated metal has merits that its tensile strength is high, that the framework is firm, and that its continuous processing property is excellent. By contrast, perforations are two-dimensionally formed, and, when a perforated metal is used as a core member for a battery electrode, the perforated metal has therefore demerits such as that the volume of the active material is reduced, that the weight of the perforated metal in the electrode core member is large, and that it is difficult to form minute perforations and minute pitches. On the other hand, a foamed metal is obtained by conducting an electroless plating process on a substrate such as urethane foam to provide the substrate with electrical conductivity, then performing electroplating, and thereafter decomposing and removing the substrate. According to the configuration, three-dimensional continuous perforations are formed. When a foamed metal is used as a core member for a battery electrode, therefore, an active material can be filled at a high density. However, foamed metal has demerits such as that the framework is thin and fragile and hence it is difficult to handle a foamed metal, that the framework has a very thin fibrous shape and therefore the flatness is hardly attained, that manufacturing steps are large in number and cumbersome and require a prolonged time period, and that it is difficult to manufacture a long member.

[0004] Therefore, it is an object of the invention to provide a thin meshy porous body which is made of a metal, a resin, or paper, which has a section of a three-dimensional structure and a high porosity, which has minute pitches, minute openings, and a firm framework, and which is light in weight. It is another object of the invention to provide a method of manufacturing a thin meshy porous body made of a metal, a resin, or paper which can continuously process a long thin porous body.

Disclosure of Invention

[0005] In the thin meshy porous body of the invention, front and rear faces of a thin plate member of a metal, a resin, or paper are embossed so that concave and convex portions of a conical shape such as a pyramidal shape or a circular conical shape are opposite to each other, and an opening is formed in a tip end of each of the convex portions in at least one face.

[0006] In the thus configured thin meshy porous body, because of the conical concave and convex portions which are formed in the front and rear faces so as to be opposite to each other, and the openings disposed in the tip ends of each convex portion in at least one face, a section has a three-dimensional structure, the porosity is high, and the framework is firm although the body is a very thin plate and has a reduced weight. Because of the conical concave and convex portions, it is possible to obtain a porous body having minute pitches and minute openings.

[0007] When the thin meshy porous body made of a metal which has a three-dimensional structure and a high porosity, which is a very thin plate, and which has a reduced weight is used as a porous electrode core member for a nickel-metal-hydride battery or the like, the filling amount of the active material can be enlarged so that the capacity is increased, and the conductivity with respect to the active material is improved, whereby a large capacity and a high output can be obtained. The porous electrode core member which is configured by a firm framework can sufficiently endure volume expansion occurring in a charging or discharging process, and is not cracked or broken even when the member is scrolled or bent so as to agree with a cylindrical or rectangular shape of a battery. Since a porous body which is made of a metal, a resin, or paper, and which has minute pitches and minute openings is obtained, the body can be suitably used also as various filter members, a support for an industrial deodorizing catalyst, or the like.

[0008] In manufacturing of the thin meshy porous body of the invention, a thin plate member of a metal, a resin, or paper is passed between a pair of embossing rolls which are rotated in opposite directions in a state where many conical projections formed on surfaces of the rolls are engaged with each other, to emboss front and rear faces of the thin plate member so that conical concave and convex portions are opposite to each other, and at the same time an opening is formed in a tip end of each of the convex portions in at least one face. According to this configuration, the thin plate member is manufactured by positive molding, and hence the framework is firm, and also the tensile strength is excellent. Therefore, it is possible to continuously process a long porous body.

Brief Description of Drawings

[0009]

Fig. 1 is a plan view of a part of a porous body.
Fig. 2 is an enlarged plan view of a part of the porous body.
Fig. 3 is a section view taken along the line A-A in Fig. 2.
Fig. 4 is a section view taken along the line B-B in Fig. 2.
Fig. 5 is a front view of a pair of embossing rolls which are used in a method of manufacturing the porous body.
Fig. 6 is a section view of opposed portions of the pair of embossing rolls shown in Fig. 5.

Best Mode for Carrying Out the Invention

[0010] In a thin meshy porous body 10 made of a metal according to the invention, as shown in Figs. 1 to 4, the front and rear faces of a thin plate member 11 of a metal such as iron, stainless steel, nickel, copper, or aluminum are embossed so that concave and convex portions 12 and 13 of a conical shape such as a quadrangular pyramid, a triangular pyramid, or a circular cone are opposite to each other, and an opening 14 is formed in a tip end of each of the convex portions 3 in at least one face as shown in the illustrated example. The porous body exhibits a mesh-like shape as a whole. Alternatively, the opening 14 may be formed in a tip end of each of all the convex portions 13 in both the front and rear faces, not only of the convex portions 13 in the one face.

[0011] The thin plate member 11 has a thickness of 80 μm or less, preferably 10 to 50 μm. In the illustrated example, the opening 14 of each of the convex portions 13 is formed into a substantially square shape. In this case, the longitudinal length (Y) is 360 to 510 μm, the lateral length (X) is 365 to 510 μm, and the opening ratio is 45 to 60%.

[0012] The metal porous body 10 is manufactured in the following manner. As shown in Figs. 5 and 6, a thin metal plate member 1 is interposed between a pair of upper and lower embossing rolls 16 and 17 which are rotated in opposite directions in a state where many conical projections 15 formed on the surfaces of the rolls are engaged with each other, to emboss the front and rear faces of the metal plate member 11 while pressingly feeding the plate member, so that the conical concave and convex portions 12 and 13 are opposite to each other, and at the same time the tip end of each of the convex portions 13 in at least one face is broken through by the tip end of the corresponding conical projection 15 to form the opening 14 in the tip end of the convex portion 13.

[0013] The conical projections 15 formed on the embossing rolls 16 and 17 are shaped into a quadrangular pyramid, a triangular pyramid, a circular cone, or the like. In the case where the conical projections 15 have a shape of a quadrangular pyramid, the concave and convex portions 12 and 13 are formed into a quadrangular pyramidal shape, and at the same time the tip end of each of the convex portions 13 is broken through by the tip end of the corresponding conical projection 5 to form the opening 14 which has a substantially rectangular shape. At this time, the convex portion 13 have a petaloid shape in which four petaloid shaped pieces 13a are developed. Since the projections 15 formed in the surfaces of the embossing rolls 16 and 17 are formed into a conical shape such as a quadrangular pyramid, a triangular pyramid, or a circular cone, the concave and convex portions 12 and 13 can be formed at minute pitches which are as small as possible, and the minute opening 14 can be formed in each of the convex portion 13, so that the opening ratio can be enhanced.

[0014] In the metal porous body 10, the front and rear faces are embossed so that the conical concave and convex portions 12 and 13 are opposite to each other, and the opening 14 is formed in the tip end of each of the convex portions 13. When the metal plate member 11 has a thickness of 10 to 50 μm, therefore, the section structure can be three-dimensionally formed to a degree of a thickness (H) of about 550 μm (see Fig. 3), and hence it is possible to obtain the metal porous body 10 of a high porosity. When the metal porous body 10 is used as a porous electrode core member for a nickel-metal-hydride battery, a lithium-ion battery, a lithium polymer battery, a nickel-cadmium battery, or the like, therefore, the filling amount of the active material can be enlarged so that the capacity is increased, and the conductivity with respect to the active material is improved, whereby a large capacity and a high output can be obtained. Since a metal porous body of minute pitches and minute openings can be obtained, moreover, the metal porous body may be suitably used as, in place of a porous electrode core member, for example, various filter members such as an air filter which is a vaporization accelerating part of a kerosene fan heater, or a filter of an oil mist separator, a support for an industrial deodorizing catalyst, or various electromagnetic wave shield members. The porous body is not restricted to a body made of a metal, and the invention may be similarly applied also to a porous body of a resin, paper, or the like.

[0015] Hereinafter, Examples 1 to 6 of the metal porous body 10 will be described.

Example 1

[0016] In the metal plate member 11 having a thickness of 25 μm made of iron (SPCC), the front and rear faces are embossed so that the concave and convex portions 12 and 13 having a quadrangular pyramidal shape are opposite to each other, and the opening 14 having a substantially rectangular shape is disposed in

the tip end of each of the convex portions 13 in only one face. In this case, with respect to the diameter of the opening 14, the longitudinal length (Y) is 382.9 μm, the lateral length (X) is 380.5 μm, the opening ratio is 54.03%, and the thickness (H) after the process (see Fig. 3) is 490.2 μm.

Example 2

[0017] In the metal plate member 11 having a thickness of 25 μm made of iron (SPCC), the front and rear faces are embossed so that the concave and convex portions 12 and 13 having a quadrangular pyramidal shape are opposite to each other, and the opening 14 having a substantially rectangular shape is disposed in the tip end of each of the convex portions 13 in only one face. In this case, with respect to the diameter of the opening 14, the longitudinal length (Y) is 507.3 μm, the lateral length (X) is 514.6 μm, the opening ratio is 54.03%, and the thickness (H) after the process is 490.2 μm.

Example 3

[0018] In the metal plate member 11 having a thickness of 40 μm made of an aluminum foil, the front and rear faces are embossed so that the concave and convex portions 12 and 13 having a quadrangular pyramidal shape are opposite to each other, and the opening 14 having a substantially rectangular shape is disposed in the tip end of each of the convex portions 13 in only one face. In this case, with respect to the diameter of the opening 14, the longitudinal length (Y) is 365.9 μm, the lateral length (X) is 365.9 μm, the opening ratio is 49.57%, and the thickness (H) after the process is 478.0 μm.

Example 4

[0019] In the metal plate member 11 having a thickness of 40 μm made of an aluminum foil, the front and rear faces are embossed so that the concave and convex portions 12 and 13 having a quadrangular pyramidal shape are opposite to each other, and the opening 14 having a substantially rectangular shape is disposed in the tip end of each of the convex portions 13 in only one face. In this case, with respect to the diameter of the opening 14, the longitudinal length (Y) is 482.9 μm, the lateral length (X) is 480.5 μm, the opening ratio is 49.57%, and the thickness (H) after the process is 478.0 μm.

Example 5

[0020] In the metal plate member 11 having a thickness of 20 μm made of a rolled copper foil, the front and rear faces are embossed so that the concave and convex portions 12 and 13 having a quadrangular pyramidal shape are opposite to each other, and the opening 14 having a substantially rectangular shape is disposed in the tip end of each of the convex portions 13 in only one face. In this case, with respect to the diameter of the opening 14, the longitudinal length (Y) is 409.8 μm, the lateral length (X) is 400.0 μm, the opening ratio is 54.28%, and the thickness (H) after the process is 485.4 μm.

Example 6

[0021] In the metal plate member 11 having a thickness of 20 μm made of a rolled copper foil, the front and rear faces are embossed so that the concave and convex portions 12 and 13 having a quadrangular pyramidal shape are opposite to each other, and the opening 14 having a substantially rectangular shape is disposed in the tip end of each of the convex portions 13 in only one face. In this case, with respect to the diameter of the opening 14, the longitudinal length (Y) is 509.8 μm, the lateral length (X) is 507.3 μm, the opening ratio is 54.28%, and the thickness (H) after the process is 485.4 μm.

Industrial Applicability

[0022] The thin meshy porous body of the invention can be suitably used as a core member for a battery electrode, various filter members, or the like.

[0023] According to the method of manufacturing a thin meshy porous body of the invention, thin meshy porous bodies can be easily mass-produced by continuous processing.

Claims

1. A thin meshy porous body **characterized in that** front and rear faces of a thin plate member are embossed so that concave and convex portions of a conical shape are opposite to each other, and an opening is formed in a tip end of each of said convex portions in at least one face.

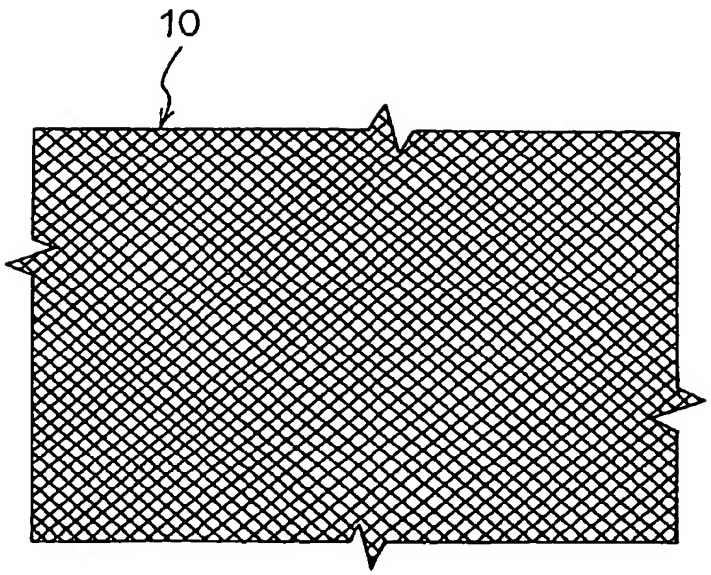
2. A thin meshy porous body according to claim 1, wherein a thickness of the plate member is 10 to 50 μm, said concave and convex portions are formed into a quadrangular pyramidal shape, said openings are formed into a substantially square shape, a longitudinal length of said openings is 360 to 510 μm, a lateral length is 365 to 510 μm, and the opening ratio is 45 to 60%.

3. A method of manufacturing a thin meshy porous body, **characterized in that** a thin plate member is passed between a pair of embossing rolls which are rotated in opposite directions in a state where many conical projections formed on surfaces of said rolls

are engaged with each other, to emboss front and rear faces of said plate member so that conical concave and convex portions are opposite to each other, and at the same time an opening is formed in a tip end of each of said convex portions in at least one face.

4. A method of manufacturing a thin meshy porous body according to claim 3, wherein said conical projections are formed into a quadrangular pyramidal shape, a thickness of the plate member is 10 to 50 μm, said concave and convex portions are formed into a quadrangular pyramidal shape, said openings are formed into a substantially square shape, a longitudinal length of said openings is 360 to 510 μm, a lateral length is 365 to 510 μm, and the opening ratio is 45 to 60%.

Fig. 1



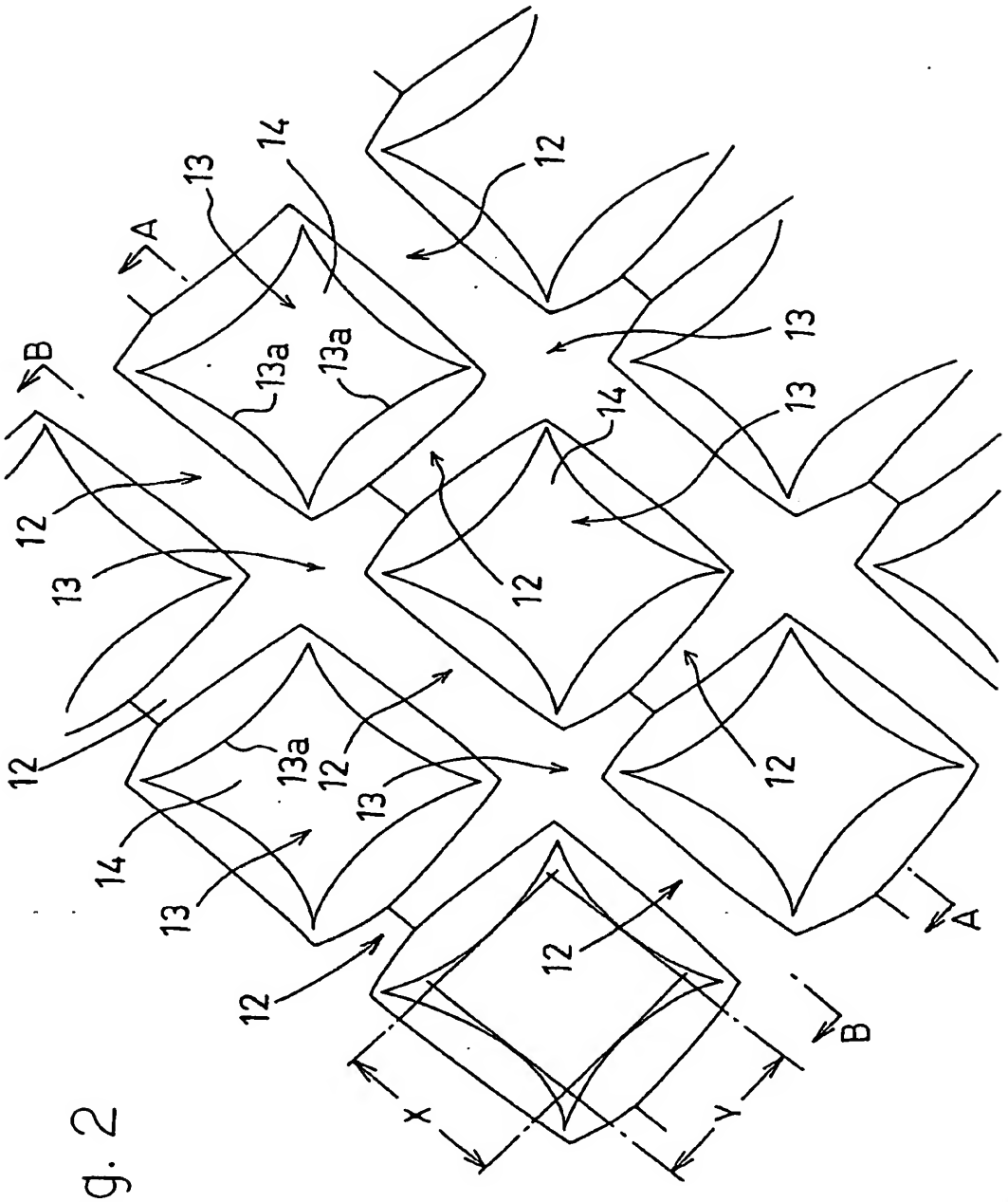
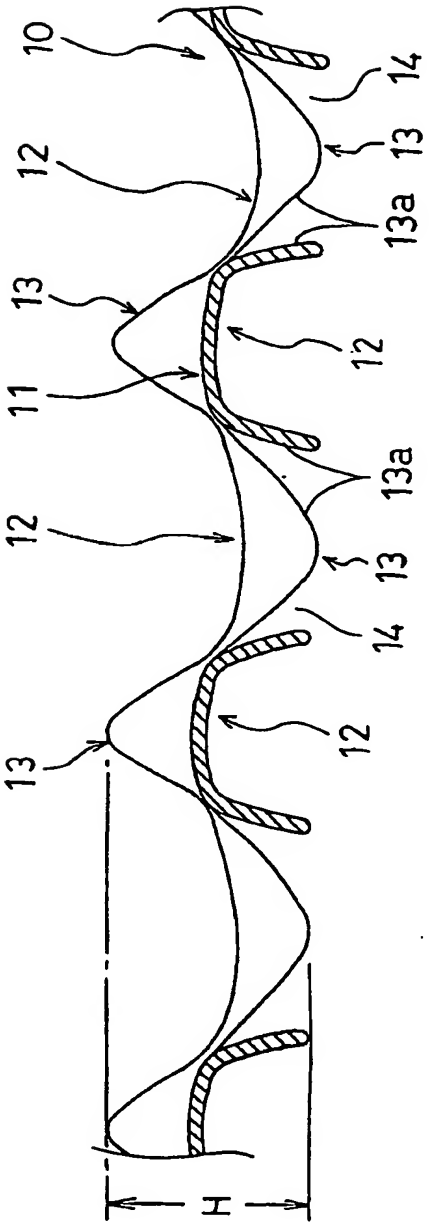


Fig. 2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H

Fig. 3

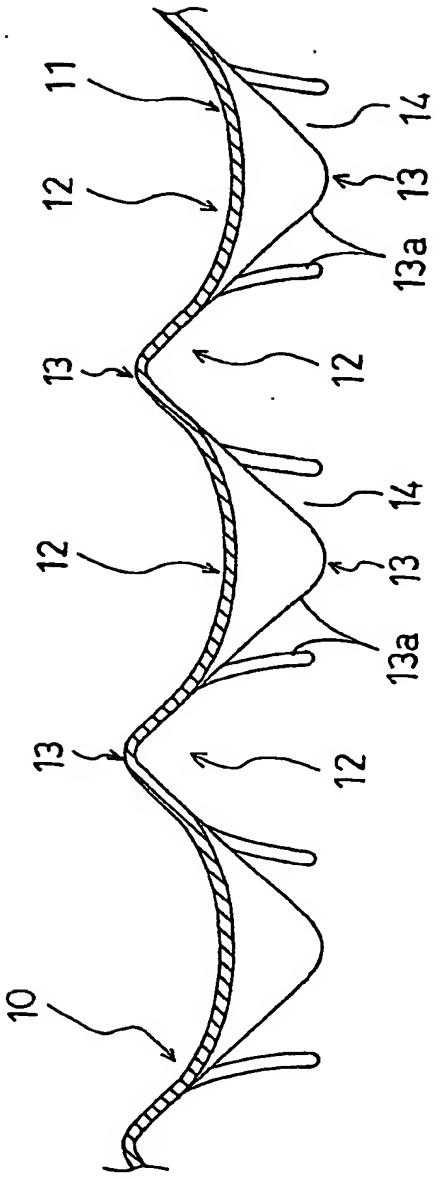
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Fig. 4

Fig. 5

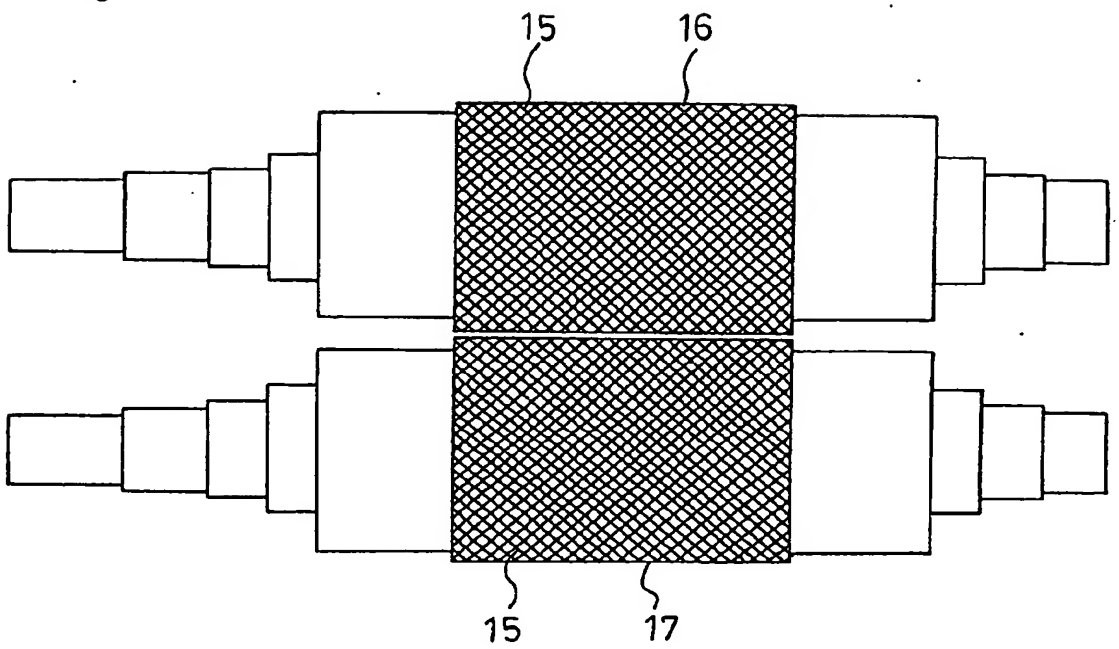
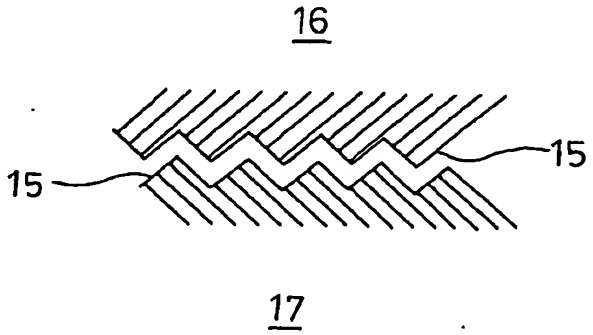


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/03301

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] H01M 4/74
B01D39/10
B21D13/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. *FIELDS SEARCHED*
Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] H01M 4/64-4/74
B01D39/10-39/12
B21D13/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2000
Kokai Jitsuyo Shinan Koho 1971-2000 Jitsuyo Shinan Toroku Koho 1996-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 11-257048 A (Nisshin Steel Co., Ltd.), 21 September, 1999 (21.09.99), page 2, Column 1, lines 2 to 5; page 3, Column 4, lines 42 to 47; page 5, Figs. 1, 2 (Family: none)	1-2
X Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No.25229/1993 (Laid-open No.79066/1994) (YUASA CORPORATION), 04 November, 1994 (04.11.94), page 2, Column 1, lines 2 to 3; Figs. 1, 2; page 4, lines 6 to 8, lines 19 to 22 (Family: none)	1-4 3-4
X Y	JP 7-335208 A (Matsushita Electric Ind. Co., Ltd.), 22 December, 1995 (22.12.95), page 2, Column 1, lines 35 to 38; line 48 to Column 2, line 2; page 4, Column 5, line 24 to Column 6, line 10; page 11, Figs. 1-4; page 12, Fig. 13 (Family: none)	1-2 3-4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 August, 2000 (24.08.00)	05 September, 2000 (05.09.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/03301

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 11-185763 A (Matsushita Electric Ind. Co., Ltd.), 09 July, 1999 (09.07.99), page 5, Column 7, lines 17 to 49;page 10; Figs. 1-4 & EP, 926752, A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 11 December, 1998 (11.12.98) page 6, Column 7, line 17 to Column 8, line 1; page 13, Figs. 1,2; page 14, Figs. 3A-3C, 4	1,3
X Y	JP 2000-48823 A (Matsushita Electric Ind. Co., Ltd.), 18 February, 2000 (18.02.00), page 2, Column 1, lines 2 to 11; lines 18 to 32; page 11, Figs. 1, 2 (Family: none)	1-2 3-4

Form PCT/ISA/210 (continuation of second sheet) (July 1992)